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Device for the transfer of water and heat between two air flows and use thereof for the humidification of fuel cell inlet gas

The present invention relates to devices for transferring water and heat between a first and a second air flow and the use thereof for humidifying the air feed to a fuel cell.

A fuel cell air feed installation comprising a device for transferring water and heat between the cathode air inlet and outlet circuits is described in document FRA-A-2 828 011, in the name of the applicant.

It is the object of the present invention to propose an improved device of this type, with a compact structure and reduced assembly costs, and having greater efficiency with low pressure drops.

For this purpose, according to one feature of the invention, the water and heat transfer device comprises a stack of at least two transfer subassemblies having a lamellar configuration, each comprising a transfer structure with hydrophilic porous materials arranged between a first structure for distributing the first air flow and a second structure for distributing the second air flow.

According to more particular features of the invention:

The transfer structure comprises at least one microporous layer and one macroporous layer, advantageously provided in the form of a support layer with long fibers, typically woven.

The porous layers of one subassembly are in local contact with the porous layers of an adjacent subassembly.

The stack is mounted pressed between fluid distribution bodies provided with members for connection to circuitry, particularly air and water circuits, for humidifying the air feed to a fuel cell.

Other features and advantages of the invention

will appear from the following description of embodiments, provided for illustration but nonlimiting, in relation to the appended drawings, in which:

- Figure 1 is a partial schematic perspective and exploded view of an embodiment of a device according to the invention; and

- Figures 2 and 3 are plan views of the distribution structures of the first and second air flows of the device in Figure 1.

As shown in Figure 1, the device according to the invention essentially comprises a stack of transfer subassemblies having lamellar configurations, each comprising a porous transfer structure inserted between a first structure for distributing the first air flow (or evaporation cell) 1 and a second structure for distributing the second air flow (or condensation cell) 2.

More precisely, the transfer structure of hydrophilic porous material comprises at least one hydrophilic microporous layer 3 in contact with a hydrophilic macroporous layer 4.

In the example shown in Figure 1, each macroporous layer 4, typically made from woven long glass or cellulose fibers, advantageously a tightly woven fiberglass fabric, is inserted between two microporous layers or membranes 3, typically made from a sintered hydrophilic plastic, advantageously of polyethersulfone (PES), bounding the transfer structures at the top and bottom.

Besides its intrinsic water transport role, the macroporous layer has a mechanical support role to provide a separation between the two microporous layers and thereby guarantee the presence of a capillary film between these two capillary walls, and also to mechanically support these microporous layers, in order to suitably withstand the pressure difference between the compartments.

The fabric preferably selected for this purpose

is a fabric of which the very long fibers remain stretched under pressure and limit the irreversible deformation of the microporous layers, while guaranteeing a transverse transport of the liquid water within the three-layer structure, and transporting the excess water produced in certain parts to the zones with insufficient water.

Each layer of the stack is typically between 1 and 5 mm thick, the pore size of the macroporous layers being between 50 and 250 microns and that of the microporous layers not exceeding 5 microns.

As shown in Figures 2 and 3, the fluid transfer structures consist of at least one, typically two polycarbonate layers, forming the image of one another by central symmetry and therefore obtainable using the same mold. Each layer consists of a frame bounding the exchange zone in which four collector holes A-D are arranged for the passage of the feed gases.

For optimized countercurrent exchange between the air flows, air guide channels 5 and 6 originate from two opposite collector holes (A to B in Figure 2 and C to D in Figure 3), intersected in a pattern determined by flow return partitions 7 offset from one passage to the other and suitable for making flow restrictions guaranteeing a turbulent air flow. The restrictions are arranged so that each passage has the same number of restrictions, thereby obtaining good control of the air distribution between the various passages.

The peripheral frame comprises recessed cutouts 8 for exposing projecting lateral zones 9 and 10 of the porous structures 3 and 4, so that, in an assembled configuration of the layers and subassemblies, a capillary relation of the various porous layers is maintained, allowing the distribution of the liquid water between these elements and the outward removal of the excess water produced in the transfer device. This outward removal of the excess water produced prevents

flooding of the porous layers, and also, thanks to the distribution thus obtained in all the layers of the excess liquid water produced in the cell, prevents the dewatering of the zones containing insufficient water. Also obtained is a phase separation function in the condensation part, where the liquid water is "sucked out" via the contact zones 9 and 10 and flows by gravity to the bottom of the device for removal via the outlet 12.

The stack of transfer and distribution structures, peripherally bonded, is pressed between end distribution bodies 20 and 21, typically also made from polycarbonate or PMMA, having slots for connection to fluid circuits of the fuel cell. In the embodiment shown, the collector C is the collector of the condensation stream for the wet gas that is introduced at the base via an inlet 10 and depleted of oxygen, that is, for the depleted air outlet of the fuel cell. This collector also has a phase separator function, the excess liquid water of the condensation stream falling downward in the lower end body for removal via a drain hole 11. The collector D is the inlet collector of the condensation stream, that is, the very wet air outlet of the cell. Correlatively, as shown in Figure 2, the collector A is the inlet collector in the evaporation stream, that is, of the dry gas flow issuing from the air compressor supplying the cell, collector B being the outlet collector of the evaporation stream, that is, of the air humidified in the device according to the invention and fed to the cell to supply it with oxygen.

After assembly, the device is peripherally enveloped in an airtight film, for example of cellophane or polyurethane, to prevent the dewatering of the porous layers during periods during which the fuel cell is not used.

Although the invention has been described in relation to particular embodiments, it is not limited

thereto, but is susceptible to modification or variants that will appear to a person skilled in the art in connection with the claims below.

In particular, in the case in which the capillary properties of the macroporous layer and the residual water film between this layer and the adjacent microporous layer permit sufficient transport of the liquid water, or in the case in which the pressure in the condensation structures 2 is very close to atmospheric pressure, there is no need to provide a seal between the macroporous layer and this transfer structure, thereby eliminating one of the microporous layers 3 with high bubble points on the condensation structure side. In this case, the macroporous layer 4 must have a higher bubble point pressure than the pressure difference between the condensation structure and atmospheric pressure.